DETAILED DESIGN REQUIREMENTS

SAN MATEO COUNTY SMART CORRIDORS PROGRAM

FOR

THE CITY AND COUNTY ASSOCIATION OF GOVERNMENTS
OF SAN MATEO (C/CAG)

Prepared by:

URS

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1.0 Introduction and Background

1.1 Introduction and Background

The City/County Association of Governments of San Mateo County (C/CAG) and the San Mateo County Transportation Authority (SMCTA) in conjunction with the California Department of Transportation (Caltrans) has initiated an effort to address the operation of the freeway and arterial roadway network in San Mateo County. The San Mateo County Smart Corridor Program is intended to benefit a variety of users including commuters, local traffic, and commercial vehicle and transit operators.

The mitigation of the impacts of non-recurring traffic congestion on local streets within San Mateo County during major freeway incidents on US-101 was identified as a high-priority project in the Smart Corridor Program. A Project Report (PR) was written that proposes the deployment of integrated Intelligent Transportation System (ITS) elements to provide local agencies and Caltrans the tools to manage this congestion. The project includes the installation of the following ITS elements:

- Directional signs (trailblazer and turn prohibition) to direct traffic;
- Fixed or pan-tilt-zoom closed-circuit television cameras at intersections and midblock locations to monitor traffic congestion and end-of-queue location;
- Communications to provide interconnect between local agency traffic signals on local streets and State operated traffic signals on State routes;
- Upgraded traffic signal controllers and/or cabinets and signal operation software systems;
- Arterial changeable message signs to inform motorists of traffic conditions (also referred to as Arterial Dynamic Message Signs in this document);
- Center-to-center communications between the proposed San Mateo County Hub (SMCHub) and the Caltrans District 4 Transportation Management Center (D4TMC) (note where TMC is used in a general manner in this document, it refers to the SMCHub, the D4TMC and local TMCs);
- Vehicle detector stations (non-intrusive or intrusive technology) on non-freeway state routes (El Camino Real) and local streets at mid-block locations.

Many of these same elements can also be used to manage traffic along the corridor during recurrent congestion. In addition to the ITS elements noted above, the following ITS elements were identified for possible deployment on future projects:

- Transit priority service at intersections;
- Emergency vehicle preemption at intersections;
- Highway Advisory Radio (HAR) transmitters and signs;
- Advance warning signs at Caltrain at-grade crossings;
- Changeable message signs for arterial travel times.

A Concept of Operations (ConOps) was prepared in October 2008 and updated in September 2009, with input from local agencies and Caltrans, and direction from the

Federal Highway Administration (FHWA). This is an initial step in the Systems Engineering process defined by the FHWA. This document identifies the stakeholders, their roles and responsibilities, their coordination with each other, and how the system will be developed.

1.2 Relevant Documents

Relevant documents include:

- FHWA/Caltrans Systems Engineering Guidebook for ITS, version 2.0, January 2007
- Final Draft ITS Infrastructure Improvement Plan, San Mateo County Alternative Route Plan, January 2008
- Draft Project Report in San Mateo County on US-101 and SR-82 from I-380 to the Santa Clara County Line, San Mateo County Smart Corridors, EA 4A9200, October 2008
- Project Study Report to Request Programming in the STIP for Phase 1of the San Mateo County Smart Corridors, March 2008
- San Mateo County Smart Corridors Projects Traffic Light Synchronization Program Funding Application March 2008
- San Mateo County Arterial Route for Traffic Incident Guide, February 2009
- San Mateo County Smart Corridors Program Concept of Operations, September 2009
- System Engineering Management Plan, San Mateo County Smart Corridors Program, version 10000.004, September 2009
- Functional Requirements, San Mateo County Smart Corridors Program, version 12000.007, September 2009
- High Level Requirements, San Mateo County Smart Corridors Program, version 13000.003, September 2009

Definitions and acronyms in this document are defined in the System Engineering Management Plan noted above.

2.0 Scope of Project

The goals of the project identified in the Concept of Operations have been modified as shown in **Table 1**.

Table 1 – Project Goals

Goal Area	Smart Corridors Program Goals
Traffic Incident Management	• Proactively manage traffic already diverted from the freeway to minimize impacts on local arterials, and return regional traffic back to the freeway as soon as possible by: o Actively managing traffic signal operations on selected routes to maximize traffic flow around a major incident and minimize delays caused by diverted freeway traffic. o Improving collection of current travel condition information along local arterials on the alternate routes.

Goal Area	Smart Corridors Program Goals
	(Future) o Providing accurate and timely route guidance information about the corridors to agency transportation managers. (Future) o Minimizing the intrusion of freeway traffic on local streets due to major freeway incidents.
Interagency Coordination	• Provide the capability for shared control and operation of the Smart Corridors components by the agencies. • Improve sharing of resources between agencies for more unified transportation management operations across jurisdictions. • Improve communications between the agencies during major freeway incidents.
Traffic Operations and Management	• Improve traffic flow within the corridor during normal operation • Share traffic information between the agencies to improve coordination and management of traffic during normal operations

3.0 Purpose of Document

3.1 Identify the detailed design requirements of the ITS Subsystems and System comprising the San Mateo County Smart Corridors Program

3.2 Expand the high level requirements previously developed

3.3 Identify the methods of verifying the detailed design requirements

3.4 Trace the requirements from the ConOps, functional requirements, and high-level requirements to the detailed design requirements.

4.0 Requirements

Note: Items in italics are carried over unchanged from the High Level Requirements Document to provide a complete document.

4.1 Overall System Requirements

4.1.1 The System shall be able to collect and display data to support the following functions at local and inter-jurisdictional levels:

- *Traffic Operations*
- *Recurrent Congestion Management*
- *Non-recurrent Congestion/Incident Management*
- *Special Event Management*
- *Seasonal Traffic Management*
- *Emergency/Disaster Management*

4.1.2 The following Subsystems are expected to be deployed as part of the San Mateo Smart Corridors Program:

- Traffic Signal Subsystem to support traffic control.
- Directional Signs Subsystem to disseminate directional arrows on alternate routes or to prohibit turn movements.
- Arterial Dynamic Message Signs (ADMS) Subsystem on arterials for information dissemination.

- CCTV Cameras Subsystem to provide traffic surveillance and incident management verification.
- Detection System Subsystem to provide traffic flow monitoring and traffic control data.
- Communications Subsystem to transmit data and video images from field elements to the TMCs.

4.1.3 The System shall work with different makes and models of equipment intended for the same purpose.

4.1.4 The System shall provide compatibility with the Bay Area C2C Interface Control Document.

4.1.5 The System shall implement only published standards with any amendments to be approved by Caltrans.

4.1.6 Standards shall include the following industry standards groups as applicable at a minimum:

4.1.6.1 NTCIP – Center-to-Center as modified for the Bay Area and as indicated in the San Mateo Smart Corridor Program ICD, dated July 2009.

4.1.6.2 NTCIP – Center-to-Field as indicated in the San Mateo Smart Corridor Program Interface Control Document (ICD), dated July 2009.

4.1.6.3 Society of Automotive Engineers (SAE) as indicated in the San Mateo Smart Corridor Program ICD, dated July 2009

4.1.6.4 Institute of Electrical and Electronic Engineers (IEEE) as indicated in the San Mateo Smart Corridor Program ICD, dated July 2009

4.1.6.5 American Association of State Highway and Transportation Officials (AASHTO) / Institute of Transportation Engineers (ITE) as indicated in the San Mateo Smart Corridor Program ICD, dated July 2009

4.1.6.6 National Electrical Manufacturers Association (NEMA)

4.1.6.7 Electronic Industries Alliance (EIA) / Telecommunications Industry Association (TIA)

4.1.6.8 Occupational Safety and Health Administration (OSHA)

4.1.7 The System shall conform to current Caltrans policies, practices and standards including:

4.1.7.1 2006 Standard Plans

4.1.7.2 2006 Standard Specs

4.1.7.3 2009 TEES

4.1.7.4 Cal / OSHA

4.1.7.5 Assembly Bill 3418E

4.1.8 All field equipment shall meet the environmental requirements of the above noted Caltrans policies, practices and standards.

4.1.9 System design shall provide backup capabilities to allow continuation of a satisfactory level of coordinated operation, should a local TMC, the SMCHub, the D4TMC, the communications hub, a communications link, a CCTV camera, a DMS, a directional sign or an intersection controller failure occur. A failure of a critical System component or intersection controller shall trigger

corrective action to related adjacent intersections. (Satisfactory level is defined as the System not experiencing failure as defined previously.)

4.1.10 *The System shall include alarms to notify operators and maintenance personnel of System and device failures.* Alarms shall be provided for the following conditions:

4.1.10.1 Communications failures

4.1.10.2 CCTV failure

4.1.10.3 ADMS failure

4.1.10.4 Detector failures

4.1.10.5 Directional sign failures

4.1.10.6 Failure of central hardware or software

4.1.11 Alarms shall be user-settable.

4.1.12 It shall be possible to establish threshold levels for determining if a device or function has failed.

4.1.13 At the local level, the System shall be capable of interfacing with existing fiber networks and System compatible controllers.

4.1.14 At the regional level, the System shall be capable of interfacing with the existing BART fiber backbone and with the D4TMC ATMS.

4.1.15 The System shall have the capability of being expanded to cover the entire corridor in the County of San Mateo.

4.1.16 The System software shall have the capability of being expanded along the Smart Corridor in San Mateo County and being expanded to the following ultimate number of devices:

- 1024 CCTV
- 1024 ADMS
- 1024 Directional Signs
- 1024 Vehicle Detector Stations
- 1024 signalized intersections

4.1.17 As devices are added to the System, this shall only involve additions to the database without a reconfiguration or redesign of the System.

4.1.18 The System shall be capable of supporting all users concurrently without a noticeable change in System performance. The system view shall not be delayed by more than 2 seconds as compared to the pilot project when the system is at ultimate size.

4.1.19 At the ultimate size, the operation of the field devices shall be unaffected by the additional devices with no increase in latency.

4.1.20 The number of users allowed to be defined in the System shall be as follows and in the level of decreasing authority:

4.1.20.1 *Administrative User* (1) - *overall control of all System functions and settings, including individually determining access rights for other levels of users*

4.1.20.1.1 *Administrative users shall have the ability to add/modify/delete users* to specific user levels and within that level to specify what they can or cannot do.

4.1.20.1.2 If a workstation is unused for an administrative user settable duration, the logon shall timeout and require the user to logon to access the System.

4.1.20.1.3 In the event of an incident resulting in Caltrans assuming System control, Caltrans shall act as an administrative user.

4.1.20.2 *Primary Users* (1024) - *ability to control and monitor all System functions.* This includes CCTV, ADMS, directional signs, intersection controllers and detection stations.

4.1.20.3 *Secondary Users* (1024) - *ability to control and monitor a limited subset of all System functions.* These would be non-Caltrans elements within a specified jurisdiction.

4.1.21 Each user account shall be unique.

4.1.22 Where users of the same level are attempting to perform the same function, the user who initiated the action first shall have priority.

4.1.23 Where a user is overridden by another user, he/she shall receive a notification of this action.

4.1.24 Users connected to the network and using a password and user identification shall be considered authorized users.

4.1.25 Users shall be able to access the System via the Internet with the same privileges as if they were on a System workstation.

4.1.25.1 Security measures shall be the same as those for a network connected user (encrypted password and user name and user level).

4.1.26 A manual command shall override a system command.

4.1.27 Depending on their access level, users shall be able to perform the following actions:

4.1.27.1 Modify central databases

4.1.27.2 Modify local/remote databases

4.1.27.3 Manually control field elements

4.1.27.4 Establish schedules for field elements

4.1.27.5 View field elements data

4.1.27.6 View field images

4.1.28 During normal operations, each Agency shall have primary privileges over field elements in their own jurisdiction.

4.1.29 The System shall be capable of collecting and displaying the following information:

- Maintenance information which can be displayed or printed by device type, location, time of day/date. Maintenance information shall include status, and if failed, the time/date of failure and the reason for the failure

4.1.30 The CCTV cameras shall be capable of being placed in at least four independent camera tours per workstation.

4.1.31 The SMCHub shall normally control and monitor the local field devices that are not owned by Caltrans. This will continue until such time as local TMC's come into existence.

4.1.32 The SMCHub shall take over for Caltrans in the event the Caltrans D4 TMC becomes unavailable. Caltrans shall be able to operate the system through a leased line to the SMCHub.

4.1.33 The primary GUI shall be an interactive map that displays current status of the roadway network and ITS field elements.

4.1.34 Data shall be geographically referenced on the NAD 83 (NAVD 88) California Coordinate System.

4.1.35 All actions by users shall be logged with the time, date, user identification and the action taken.

4.1.36 The System shall provide a user with spell check, text wrapping and copy/cut/paste capabilities on reports and sign messages.

4.1.37 The user shall be able to specify the format of reports and the data to be included in the reports.

4.1.38 The System shall have the ability to create reports containing current and historical data. *The System shall support the ability for multiple users to monitor the same data items.*

4.1.39 The System shall not require input from other systems to function.

4.1.40 *The System shall support compliance with all interagency agreements.*

4.1.41 Subsystems shall continue to operate with the same functions in the event that other Subsystems are not available. If communications still exist, the Subsystems shall have full functionality. I f communications does not exist, the field devices shall be capable of being operated locally either manually or on a time of day basis as applicable.

4.1.42 Each Subsystem shall be able to perform the same functions as a standalone system that it will perform within the integrated System.

4.1.43 In the event of a power failure at the D4TMC, the SMCHub, the local TMC's, or at the field elements, the affected System/Subsystem/field element shall revert to the power backup available locally.

4.1.44 Through the use of external cabinets or by having equipment in separate cabinets, it shall be possible to establish a demarcation point for defining the limits of maintenance responsibility for communication lines, all field equipment and all TMC equipment.

4.1.45 Upon confirmation of a major incident on US 101, Caltrans shall have the ability to take over control of all ITS devices on affected local roadways.

4.1.45.1 The initial response to a major incident will involve the automatic implementation (following Caltrans user approval) of a predetermined response plan.

4.1.45.2 Caltrans shall have the ability to select response plans manually and to manually change all timing plans.

4.1.45.3 Local TMCs and the SMCHub will maintain the ability to monitor ITS devices in a manner identical to that prior to their takeover by Caltrans.

4.1.45.4 Local agencies will not be able to control any System elements once Caltrans has implemented a response plan.

4.1.45.5 *Local agencies will have the ability to view the signal timing plans in effect and any changes made to them by Caltrans.*

4.1.46 The System shall synchronize clocks with all field devices using Pacific Standard Time.

4.1.47 Within each Subsystem, the components shall be capable of being added in a modular fashion.

4.1.48 (This line left blank to preserve numbering.)

4.1.49 Proprietary protocols shall be used only when necessary to communicate to legacy and third party devices that do not support NTCIP communications protocols. To facilitate exchange of information, the standards/interfaces not specified elsewhere in this document shall be non-proprietary, well-documented, capable of being implemented by several firms, in widespread use, supported and maintained by national organizations and follow industry standards.

4.1.50 Changes in the database resulting from future expansion and additional ITS elements shall involve a smooth and seamless integration.

4.1.51 The System shall have a standalone interface for a user in the D4TMC until such time as the System is integrated into the D4ATMS at which time the interface shall be transparent to the user in the D4TMC.

4.1.52 It shall be transparent to the user whether the System is a single system or multiple, interconnected systems.

4.1.53 The System provided shall demonstrate three different examples of successful operations and integration with other established and similar Systems.

4.1.54 The System shall be vendor- and model-independent.

4.1.55 The delivered and installed System shall be fully documented. This documentation shall consist of pertinent technical documentation and user documentation sufficient to maintain and operate the System.

4.1.56 Software and hardware shall be reliable. Reliability shall be measured by the following methods:

4.1.56.1 The percentage of time that the System is available for use shall be at least 99.8% measured over a 30-day period. This excludes scheduled maintenance which should not involve shutting down the System or any Subsystem longer than 1 hour in a 30-day period.

4.1.56.2 In the event of a power failure, the System shall resume normal scheduled operation within 5 minutes of restoration of power. Normal operation is defined as operation of the complement of devices meeting the performance requirements and providing the functionality noted herein.

4.1.56.3 System failure shall occur when the user is unable to access the System and perform normal operations; when more than 10% of a given type of ITS element is not available; when more than 10% of the total ITS elements are not available for use. Power failures at field locations are not to be counted in these calculations.

4.1.56.4 In the event of a failure or the System not meeting the performance requirements, the System shall be considered not meeting the system requirements.

4.1.57 System performance measures shall be based on reliability measures and on the following:

4.1.57.1 Displays shall be available within 2 seconds after a user command
4.1.57.2 Screen updates shall occur within 2 seconds
4.1.57.3 These requirements shall apply to items including but not limited to status reports, detector data reports, directional sign message reports, and CCTV images.

4.2 Traffic Control Subsystem

4.2.1 Within a jurisdiction, the Subsystem shall be capable of the following modes of operation on a system-wide basis, a group basis or as individual intersections:
- *4.2.1.1 Time-of-day operation*
- *4.2.1.2 Traffic responsive operation* (defined separately for Caltrans and agency operations)
- *4.2.1.3 Manual operation*
- *4.2.1.4 Flash operation* (with a confirmation message sent to the operator)
- *4.2.1.5 Free actuated operation*

4.2.2 Traffic responsive operation shall be based on a combination of occupancy and volume data from system detectors.

4.2.3 The application shall launch and operate within a web browser and shall not utilize any 3rd party remote web access, web application delivery or virtual networking tools to achieve/simulate a web application.

4.2.4 The map shall be GIS based using standard GIS files (e.g. .shp files or other equivalent) to render a geographically accurate, to-scale map.

4.2.5 The Subsystem shall provide authorized users the capability to view the following signalized intersection information:
- 4.2.5.1 Location and jurisdiction
- 4.2.5.2 Signal controller and vehicle detection hardware
- 4.2.5.3 Communication type and status
- 4.2.5.4 Signal controller status defined by AB3418
- 4.2.5.5 All user settable signal controller parameters
- 4.2.5.6 Alarms

4.2.6 The Subsystem shall provide authorized users the capability to alter signal controller parameters listed in 4.3.2.

4.2.7 The Subsystem shall be capable of restricting the alteration of signal controller parameters listed in 4.3.3.

4.2.8 The Subsystem shall allow groups of controllers to be created and controlled independent of jurisdictional boundaries.

4.2.9 The Subsystem shall allow signal coordination across jurisdictional boundaries.

4.2.10 Users can assign intersections to groups on a time of day basis and on a traffic responsive basis.

4.2.11 The Subsystem shall utilize a common system time reference, and clocks shall be synchronized at least once every hour.

4.2.12 Authorized users shall be able to select the Subsystem's mode of operation at any time.

4.2.13 The Subsystem shall provide data on intersection operation including timing plans and intersection status which can be displayed or printed by intersection name or intersection number.

4.2.14 The Subsystem shall provide historical signal timing data which can be displayed or printed by time-of-day, interval, location and group

4.2.15 Once an operating mode is selected, the Subsystem shall begin implementation of selected mode within one cycle length.

4.2.16 In the event of a loss of communications to a Subsystem being controlled at the SMCHub or D4TMC level, the Traffic Control Subsystem shall revert to local control / time-of-day schedules.

4.2.16.1 If communication to a controller is lost, the controller shall continue to operate under the most recent mode of operation to the extent possible.

4.2.16.2 If communication to a group of controllers is lost, the group shall continue to operate under the most recent mode of operation to the extent possible.

4.2.17 The Traffic Control Subsystem shall have the following performance measures

4.2.17.1 The percentage of time that the Subsystem is functioning shall be at least 99.8% measured over a 30-day period. This excludes scheduled maintenance.

4.2.17.2 In the event of a power failure, the Subsystem shall resume normal scheduled operation within 3 minutes of restoration of power.

4.3 Traffic Signal Controllers

4.3.1 Controllers shall be capable of operating under the following modes:

4.3.1.1 Time-of-day operation

4.3.1.2 Traffic responsive operation

4.3.1.3 Manual operation

4.3.1.4 Flash operation

4.3.1.5 Free actuated operation

4.3.2 Controllers shall be able to receive and implement timing plans from the System that alter the following parameters:

4.3.2.1 Splits

4.3.2.2 Cycle lengths

4.3.2.3 Green extensions

4.3.2.4 Offsets

4.3.2.5 Lead/Lag

4.3.2.6 Recalls

4.3.2.7 Phase Omit

4.3.2.8 Clearance Times

4.3.2.9 Gap Times

4.3.3 The Subsystem shall provide processing of emergency vehicle preemption.

4.3.4 The Subsystem shall have the capability to export signal timing plan data.

4.3.5 Controllers shall be capable of storing at least 32 unique signal timing plans.

4.3.6 Controllers shall continue to operate normally during all communication polling and database transfers.

4.3.7 Controllers shall meet either NEMA TS2, or be compatible with Model 2070 or Model 2070 Lite requirements in the TEES.

4.3.8 Controllers shall have the following performance measures:

4.3.8.1 The percentage of time that a controller is functioning shall be at least 99.8% measured over a 30-day period. This excludes scheduled maintenance.

4.3.8.2 In the event of a power failure, the controller shall resume normal scheduled operation within 3 minutes of restoration of power. (Normal as previously defined.)

4.4 Directional Sign Subsystem

4.4.1 The Directional Sign Subsystem shall be composed of signs noting the direction of travel (trailblazers) and signs prohibiting specified directions of travel.

4.4.2 Trailblazer signs shall direct the motoring public to designated routes through the use of arrows.

4.4.3 The Subsystem trailblazer signs shall be capable of displaying non-flashing and flashing arrows.

4.4.4 Trailblazer signs shall have a dynamic arrow capable of showing multiple directions either singly or concurrently.

4.4.5 Trailblazer signs shall be uniquely identifiable.

4.4.6 Turn prohibition signs shall be blankout signs.

4.4.7 The Subsystem shall be able to report the status of all sign hardware.

4.4.8 Sign placement *shall conform to the Manual of Uniform Traffic Control Devices (MUTCD).*

4.4.9 The Subsystem shall allow sign messages to be centrally validated. Validation shall consist of checking the authority of the user, and verifying the sign is off or the correct arrow display is being displayed.

4.4.10 Users shall have the capability to poll a directional sign to view/confirm current sign displays, equipment status, and to test communications.

4.4.11 The Subsystem shall be able to automatically report the status of all internal electronic components, and communication equipment.

4.4.12 The Subsystem shall be capable of displaying messages on a scheduled basis with the start/end times established by the user.

4.4.13 The sign controller shall be able to retain user and scheduled plan commands in the event of a sign failure or loss of communications to a sign and implement these commands when the sign resumes normal function if the command is valid and has not expired.

4.4.14 The Subsystem shall be capable of displaying messages for a user-settable length of time.

4.4.15 The user shall be able to implement a command to a single sign or a group of signs at once.

4.4.16 Turn prohibition signs shall comply with MUTCD.

4.4.17 Directional signs shall have the following performance measures:

4.4.17.1 The percentage of time that the Subsystem is functioning shall be at least 99.8% measured over a 30-day period. This excludes scheduled maintenance.

4.4.17.2 In the event of a power failure, the Subsystem shall resume normal scheduled operation within 3 minutes of restoration of power.

4.5 ADMS Subsystem

4.5.1 *The Subsystem shall allow sign messages to be centrally validated.* Validation shall consist of checking the authority of the user, spell check, comparing the message against a list of unacceptable words and viewing message content.

4.5.2 Users shall have the capability to manually poll an ADMS to view/confirm current sign messages, equipment status, sign temperature and to test communications.

4.5.3 The Subsystem shall be able to automatically report the status of all sign hardware including individual pixels, internal electronic components, temperature and communication equipment.

4.5.4 The Subsystem shall be capable of displaying messages on a scheduled basis with the start/end times established by the user.

4.5.5 The Subsystem shall be capable of displaying messages for a user-settable length of time.

4.5.6 The user shall be able to compose or retrieve a message and post it to a single sign or a group of signs at once.

4.5.7 The user shall be able to blank a sign or a group of signs at once.

4.5.8 The user shall be able to view a message before it is transmitted, and the users view shall be the same as what is displayed on the sign (WYSIWYG) with an exact pixel representation.

4.5.9 The Subsystem shall be capable of displaying either a 1 or 2 phase message.

4.5.10 Each ADMS shall display 2 lines of text with 12 12-inch high characters per line.

4.5.11 The sign controller shall be able to retain user, scheduler, and response plan commands in the event of a sign failure or loss of communications to a sign and implement these commands when the sign resumes normal function if the command is valid and has not expired.

4.5.12 The Subsystem shall support NTCIP 1203 (Ver. 2.35a Published 2007)

4.5.13 ADMS shall have the following performance measures:

4.5.13.1 The percentage of time that the Subsystem is functioning shall be at least 99.8% measured over a 30-day period. This excludes scheduled maintenance.

4.5.13.2 In the event of a power failure, the Subsystem shall resume normal scheduled operation within 3 minutes of restoration of power.

4.6 CCTV Subsystem

4.6.1 The Subsystem shall support the video monitoring of selected arterial locations and midblock locations to provide information regarding traffic conditions.

4.6.2 Each CCTV camera shall transmit a color image.

4.6.3 Camera images shall conform to National Television System Committee (NTSC) standards.

4.6.4 The user shall be able to select and view any CCTV camera in the Subsystem.

4.6.5 CCTV images from all cameras shall be viewable sequentially (camera tours), individually or simultaneously as a group

4.6.6 All video shall be a minimum of 10 frames per second.

4.6.7 The Subsystem shall support both PTZ and fixed cameras.

4.6.8 CCTV cameras shall have multiple control functions such as focus, presets, iris adjustments as well as pan, tilt and zoom (if so equipped) which can be accessed locally and remotely.

4.6.9 The Subsystem shall support serial and/or IP communication for camera control.

4.6.10 The Subsystem shall support multiple camera controllers using different protocols.

4.6.11 Each video image shall have a unique identification which can be modified by a user with a suitable access level.

4.6.12 The capability shall exist to share control of cameras among agencies within the corridor including Caltrans.

4.6.13 (This line left blank to preserve numbering.)

4.6.14 The CCTV Subsystem shall have the following performance measures;

4.6.14.1 The percentage of time that the Subsystem is functioning shall be at least 99.8% measured over a 30-day period. This excludes scheduled maintenance.

4.6.14.2 In the event of a power failure, the Subsystem shall resume normal scheduled operation within 3 minutes of restoration of power.

4.7 Detection Subsystem

4.7.1 The Subsystem shall provide for measurement of traffic parameters (speed, volume and occupancy on a per lane basis) at selected locations.

4.7.2 The Subsystem shall provide volume, speed, occupancy and status data which can be displayed or printed by time period, location, lane, station and group.

4.7.3 The Subsystem shall collect data at a minimum data accumulation period of once every 30 seconds.

4.7.4 After the end of each data accumulation period, the data for that time period shall be made available to the System

4.7.5 The Subsystem shall provide historical detector data which can be displayed or printed by time of day, interval, location and group.

4.7.6 The System shall be capable of interfacing with all legacy vehicle detector sensors.

4.7.7 System detectors shall collect/calculate volume, occupancy, and speed data independent of local signal controller actuation and detection functions.

4.7.8 The Detection Subsystem shall have the following performance measures:

4.7.8.1 The percentage of time that the Subsystem is functioning per the specifications shall be at least 99.8% measured over a 30-day period. This excludes scheduled maintenance.

4.7.8.2 In the event of a power failure, the Subsystem shall resume normal scheduled operation within 3 minutes of restoration of power.

4.8 Communications Subsystem

4.8.1 The Communications Subsystem shall be able to incrementally increase or decrease in size with limited cost and risk as the need to add or remove equipment becomes necessary. A design utilizing modular communication equipment shall be provided.

4.8.2 The Communications Subsystem shall be capable of supporting any combination of private twisted-pair copper, fiber optic, and/or wireless radio.

4.8.3 The Communication Subsystem shall support serial and Ethernet based communications.

4.8.4 The Communications Subsystem shall provide capability for center-to-field (C2F) communications connecting and supporting all ITS (CCTV video surveillance, arterial detection, directional and arterial dynamic message signs) and various traffic signal field devices within the project area with the San Mateo County Hub (SMCHub) and the Caltrans District 4 Transportation Management Center (D4TMC).

4.8.4.1 The Communications Subsystem shall include Hubs at selected locations along the corridor to aggregate communications network data and video and support alternate configurations up to the ultimate system size.

4.8.4.2 Provide direct Ethernet communications between the HUBs and the SMCHub.

4.8.4.3 The Communications Subsystem shall support interconnect and coordination between local agency traffic signal systems on local streets (local TMCs/TOCs), the SMCHub and State operated traffic signals on State routes (D4TMC).

4.8.5 The Communications Subsystem shall provide capability for center-to-center (C2C) communications between the proposed SMCHub and the D4TMC.

4.8.5.1 Provide a SONET OC-X node (as determined by Caltrans) at the SMCHub to create a redundant SONET ring through the existing Caltrans SONET backbone network connecting the SMCHub, D4TMC, SFGo TMC and others.

4.8.5.2 Support and provide compatibility with the on-going Smart Corridor C2C Interface Control Document (ICD) and central software initiatives.

4.8.6 The SMCHub shall serve as the central local control point of the Smart Corridor and serve as back-up for Caltrans D4TMC operations.

4.8.7 New backbone fiber optic cable shall be a minimum of 72 single mode fibers or as required during design with a minimum of one (1) buffer tube allocated for backbone communications purposes only.

4.8.8 New spur (drop) fiber optic cable shall be sized for the application.

4.8.9 Communications equipment shall include Ethernet switches. Each switch shall provide at least eight (8) copper ports (sized for application during design) with a minimum speed of 100 Mbps and two pluggable, single-mode 100/1000 Mbps full duplex fiber ports for "daisy-chain" applications. Optical transceivers shall be as required to meet link loss budget requirements determined per the design.

4.8.10 All field Ethernet switches shall support, at a minimum; multicast routing (IGMP snooping), Virtual LAN (802.1Q), Simple Network Management Protocol (SNMP) capable, Spanning Tree Protocol / STP (IEEE 802.1D including the rapid spanning tree protocol / RSTP extension) and browser-based management interface.

4.8.11 Any wireless communications providing access to and control of multiple ITS devices or creating a link to multiple wireless devices shall be considered to be part of the communications backbone.

4.8.12 All design of wireless links shall include a full path analysis as required.

4.8.13 The communications network shall provide sufficient bandwidth and network configuration to support full motion video up to 30 frames per second (with a minimum of 10 frames per second) from all cameras and field data devices simultaneously as part of this System. Any camera shall be able to be viewed simultaneously by any and all operators and/or authorized users with network connectivity.

4.8.14 All communications field equipment shall be hardened complying with the NEMA TS1 and TS2 Environmental Requirements for traffic control equipment. Where there is a conflict with other requirements, the more stringent requirement shall apply

4.8.15 All communications field equipment shall be protected and able to maintain normal operations under local adverse roadway conditions including; wind blown dust, dirt, rain, salt environment, etc.

4.8.16 The Communications Subsystem shall be expandable to accommodate at least 25% more field devices of each type than currently planned and accommodate a minimum of 30% excess bandwidth for future network traffic.

4.8.17 The communications network and associated equipment shall be readily and safely accessible for maintenance and capable of being maintained by electronic technicians with a normal skill set and equipment normally available for maintenance of a fiber optics and/or wireless communication system as applicable.

4.8.18 Diagnostics shall be provided via visual displays on the equipment or output to a port connected to a laptop.

4.8.19 The Subsystem shall include a network management system (NMS) providing the following minimum features:

4.8.19.1 Provide a graphical, layered view of the communication system architecture.

4.8.19.2 Manage the bandwidth of the network.

4.8.19.3 Configure the network and diagnose network problems from a remote location.

4.8.19.4 Report system status.

4.8.19.5 Monitor network performance.

4.8.19.6 Alert user during cable cut, hub failure, and system failure.

4.8.19.7 Provide automatic recovery with RSTP. The System shall provide a recovery time of less than five (5) seconds using industry-standard protocols.

4.8.19.8 Provide databases for storing data that fully and precisely defines and describes every element (communication link, levels and device) in the communications system.

4.8.19.9 Allow event logging and reporting.

4.8.20 The Subsystem shall include back-up power systems for communications network equipment for directional signs, hubs and traffic signals in all field cabinets, HUBs, and TMCs and other designated facilities. Run-time shall be determined during design.

4.8.21 ITS devices requiring different transmission speeds and communication protocols shall be capable of coexisting on the same communication channel.

4.8.22 The same type of ITS device from multiple manufacturers shall be capable of operating on the same communications channel (interchangeable).

4.8.23 Multiple types of ITS devices from multiple manufacturers shall operate on the same communications channel (interoperability).

4.8.24 The communication equipment specified in the design shall demonstrate technology maturity (been in use at least three years in similar systems) through successful operations and integration with other established and working systems.

4.8.25 The Subsystem shall provide the following security measures at a minimum:

4.8.25.1 Firewalls at facilities as required and approved by Caltrans.

4.8.25.2 Computer workstations shall include user passwords and administrative privileges supporting different levels of control prioritization as approved by Caltrans.

4.8.25.3 Field network devices shall include password security, remote access security, SNMP authentication and encryption, secure web

authentication and encryption, Radius support, port security and MAC filtering, at a minimum.

4.8.25.4 Physical security measures for Field Cabinets, HUBs, pull boxes, and facilities shall be provided to mitigate unauthorized entry and vandalism.

4.8.26 The Communication Subsystem shall have the following performance measures:

4.8.26.1 Point-to-point wireless serial communications may be unlicensed wireless communications (frequency hoping, spread spectrum). Bandwidth shall be determined during detailed design depending on type of device (i.e., data only, video, etc.).

4.8.26.2 Any Broadband wireless (backbone) radios contained in the communications backbone for this project shall provide a minimum bandwidth of 50 Mbps full-duplex / 100 Mbps aggregate. The first backbone link shall have a round trip latency not to exceed three (3) milliseconds with an additional five (5) milliseconds for every repeater (hop) as required after that (if the System will be using licensed "carrier-grade" equipment) or 10 milliseconds per hop (if using unlicensed equipment). All system reliability and uptime calculations shall be determined during design and approved by Caltrans.

4.8.26.3 Overall Communications Subsystem network backbone uptime (uptime being the Communications Subsystem is available to perform the required tasks) shall meet or exceed 99.5% over a 30-day period or as determined during design. This excludes scheduled maintenance.

4.8.26.4 The Communications Subsystem shall have an error rate of less than one (1) in a million.

4.8.26.5 In the event of a power failure, the Subsystem shall resume normal scheduled operation within 3 minutes of restoration of power. (Normal as previously defined.)

4.8.26.6 The Communications Subsystem shall provide for a video latency (from video encoder to decoder) of less than 400 millisecond maximum latency (or as directed by Caltrans).

4.9 Interface to Regional TMCs / D4TMC

4.9.1 Shared Video: All video images from CCTV cameras located within the project should be accessible to any jurisdiction or local agency throughout the corridor on any remote computer attached to the network.

4.10 Interface between Local Signal Systems

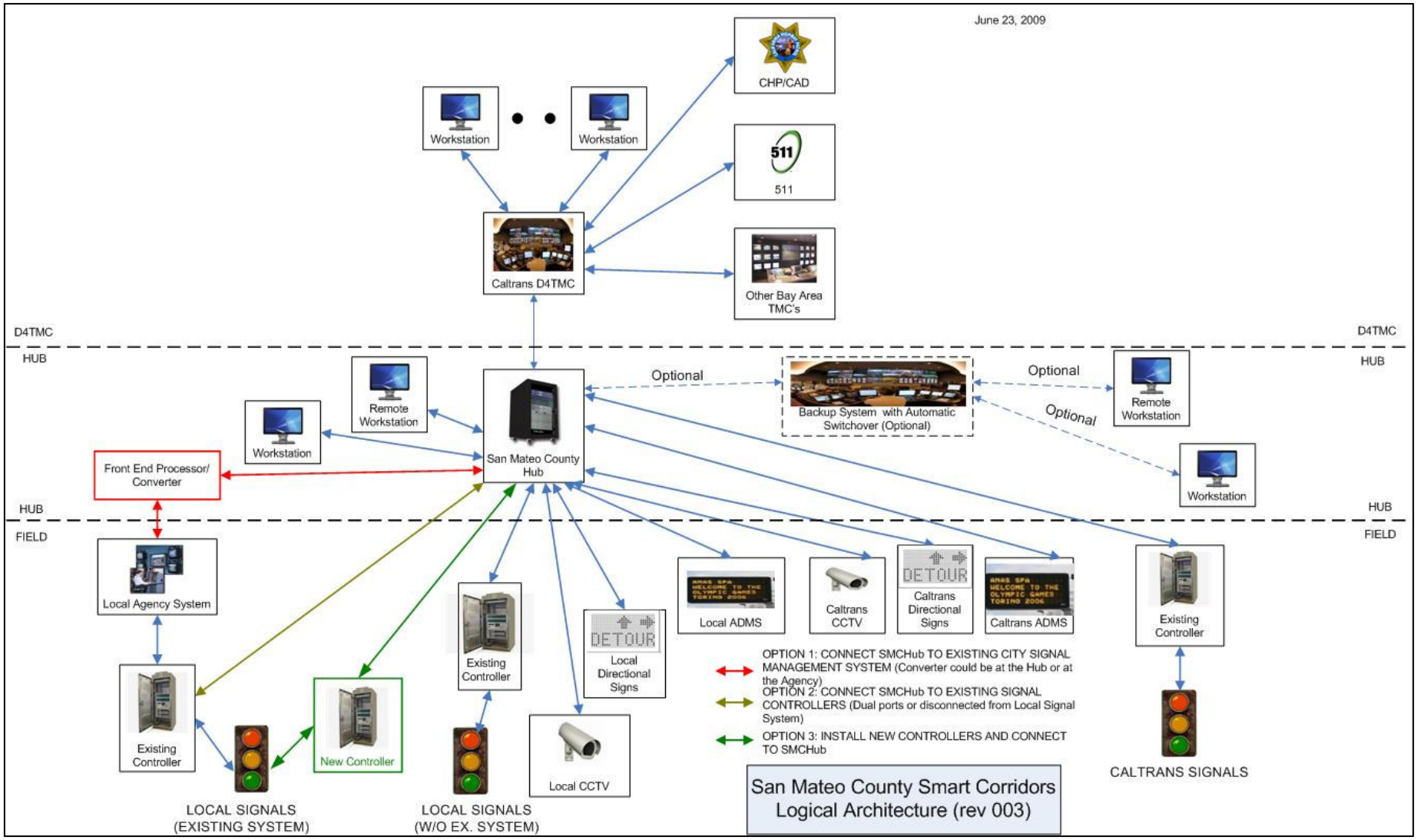
4.10.1 The connection between the local agency TMCs (if they exist) and each other as well as their connection to the D4TMC shall be through the SMCHub.

5.0 LOGICAL ARCHITECTURE

The logical architecture for the San Mateo Smart Corridors Project is shown in Figure 1. This configuration is based on the SMCHub acting as a backup for the D4TMC and overseeing the operation of non-Caltrans ITS elements until such time the local TMCs take control.

It should be noted this is the logical architecture. The physical architecture will most likely be completely different.

Figure 1 - Logical Architecture



Appendix 1
Traceability Matrix

Traceability follows a requirement throughout the life of the System. It is a key cross-cutting process that helps to ensure that all requirements are met. Traceability also supports impact analysis and configuration management for long term maintenance, changes, upgrades and replacements. The attached matrix traces requirements from the planning phase to the design phase in the following order:

- Concept of Operations
- Functional Requirements
- High Level Requirements
- Detailed Design Requirements

TRACEABILITY MATRIX-SAN MATEO COUNTY SMART CORRIDORS PROGRAM-SYSTEM ENGINEERING

ConOps Reference Section	ConOps Description	Functional Requirements Section	Functional Requirements Description	High Level Requirements Reference Section	High Level Requirements Description	Detailed Design Requirements Reference Section	Detailed Design Requirements Description	Test Procedure	Comments
3.1	**Incident Management**								
3.1.1	Install trailblazers on designated routes to guide traffic	5.3.1	Direction information on alternate routes shall be provided to motorists.	4.1.31	Upon confirmation of a major incident on US-101, Caltrans shall have the ability to take over control of all ITS devices on affected local roadways.	4.1.45	Same as High Level Requirement		
				4.4.1	The Directional Sign Subsystem shall be composed of signs noting the direction of travel (trailblazers) and signs prohibiting specified directions of travel.	4.4.1	Same as High Level Requirement		
						4.4.5	Trailblazer signs shall be uniquely identifiable		
				4.4.3	Turn prohibition signs shall prohibit turn movements.	4.4.6	Turn prohibition signs shall be blankout signs.		
				4.4.5	The Subsystem trailblazer signs shall be capable of displaying static and flashing arrows.	4.4.3	The Subsystem trailblazer signs shall be capable of displaying non-flashing and flashing arrows.		
				4.4.6	Trailblazer signs shall be capable of dynamically showing multiple directions either singly or concurrently.	4.4.4	Same as High Level Requirement		
						4.4.6	Turn prohibition signs shall be blankout signs		
		5.3.3	Signage shall be used to help manage the surface transportation system	4.4.1	The Directional Sign Subsystem shall be composed of signs noting the direction of travel (trailblazers) and signs prohibiting specified directions of travel.	4.4.1	Same as High Level Requirement		
						4.4.5	Trailblazer signs shall be uniquely identifiable		
						4.4.12	The Subsystem shall be capable of displaying messages on a scheduled basis with the start/end times established by the user.		
						4.4.15	The user shall be able to implement a command to a single sign or a group of signs at once.		
						4.5.6	The user shall be able to compose or retrieve a message and post it to a single sign or a group of signs at once.		
						4.5.7	The user shall be able to blank a sign or a group of signs at once.		

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ConOps Reference Section	ConOps Description	Functional Requirements Section	Functional Requirements Description	High Level Requirements Reference Section	High Level Requirements Description	Detailed Design Requirements Reference Section	Detailed Design Requirements Description	Test Procedure	Comments
		5.3.4	Enroute traveler information shall be provided to the motorist.	4.4.2	Trailblazer signs shall direct the motoring public to designated routes.	4.4.2	Trailblazers shall…use arrows		
				4.5.4	The System shall be capable of displaying messages for different lengths of time.	4.5.4	The Subsystem shall be capable of displaying messages on a scheduled basis…		
						4.5.5	The Subsystem shall be capable of displaying messages for a user-settable length of time		
				4.5.5	The Subsystem shall be able to display multiple messages.	4.5.9	The Subsystem shall be capable of displaying either a 1- or 2-phase message		
3.1.2	Integrate traffic incident management strategies across multiple local agencies and Caltrans	5.1.4	The System shall support operation by multiple concurrent users/operators.	4.1.16	The System shall support the ability for multiple users to monitor the same data item.	4.1.38	*The System shall have the ability to create reports* containing current and historical data. *The System shall support the ability for multiple users to monitor the same data items.*		
				4.1.18	The System shall allow each Agency to exercise full control over ITS elements owned by that Agency.	4.1.28	During normal operations, each Agency shall have primary privileges over field elements in their own jurisdiction		
				4.1.23	The System shall support authorized user access via the internet	4.1.25	Users shall be able to access the System via the Internet with the same privileges as if they were on a System workstation		
						4.2.3	The application shall launch and operate within a web browser and shall not utilize any 3rd party remote web access, web application delivery or virtual networking tools to achieve/simulate a web application.		
				4.1.25	The System shall support compliance with all interagency agreements.	4.1.40	Same as High Level Requirement		
		5.2.2	The Subsystem shall be capable of controlling and monitoring the operation of traffic signal equipment at selected intersections.	4.1.26	The System shall be capable of being controlled and monitored from local TMCs, the SMCTMS and the D4TMC	4.1.51	The System shall have a standalone interface for a user in the D4TMC until such time as the System is integrated into the D4ATMS at which time the interface shall be transparent to the user in		

TRACEABILITY MATRIX-SAN MATEO COUNTY SMART CORRIDORS PROGRAM-SYSTEM ENGINEERING

ConOps Reference Section	ConOps Description	Functional Requirements Section	Functional Requirements Description	High Level Requirements Reference Section	High Level Requirements Description	Detailed Design Requirements Reference Section	Detailed Design Requirements Description	Test Procedure	Comments
							the D4TMC		
						4.1.52	It shall be transparent to the user whether the System is a single system or multiple, interconnected systems.		
						4.4.9	The Subsystem shall allow sign messages to be centrally validated.		
				4.3.1	Signal controllers shall be capable of operating under the following modes: time of day, traffic responsive, manual, flash, and free actuated.	4.3.1	Same as High Level Requirement		
						4.3.5	Controllers shall be capable of storing at least 32 unique signal timing plans		
				4.3.2	Controllers shall be able to receive and implement timing plans from the System that alter the following parameters: splits, cycle lengths, green extensions, offsets, lead/lag, and recalls.	4.3.2	Same as High Level Requirement		
		5.1.15	Control during incidents shall be from the D4TMC	4.1.5	The System shall conform to current Caltrans policies, practices and standards.	4.1.7	The System shall conform to current Caltrans policies, practices and standards, including:		
						4.1.8	All field equipment shall meet the environmental requirements of the above noted Caltrans policies, practices and standards		
						4.3.7	Controllers shall meet either NEMA TS2, or be compatible with Model 2070 or Model 2070 Lite requirements in the TEES		
3.1.3	Implement devices to manage freeway traffic that diverts around major incidents	5.3.1	Direction information on alternate routes shall be provided to motorists.	4.1.31	Upon confirmation of a major incident on US 101, Caltrans shall have the ability to take over control of all ITS devices on affected local roadways.	4.1.45	Same as High Level Requirement		
						4.2.5	The Subsystem shall provide authorized users the capability to view the following signalized intersection information:		
				4.4.1	The Directional Sign Subsystem shall be composed of signs noting the direction of travel (trailblazers) and signs prohibiting specified directions of travel.	4.4.1	Same as High Level Requirement		

TRACEABILITY MATRIX-SAN MATEO COUNTY SMART CORRIDORS PROGRAM-SYSTEM ENGINEERING

ConOps Reference Section	ConOps Description	Functional Requirements Section	Functional Requirements Description	High Level Requirements Reference Section	High Level Requirements Description	Detailed Design Requirements Reference Section	Detailed Design Requirements Description	Test Procedure	Comments
						4.4.5	Trailblazer signs shall be uniquely identifiable		
				4.4.3	Turn prohibition signs shall prohibit turn movements.	4.4.6	Turn prohibition signs shall be blankout signs.		
				4.4.5	The Subsystem trailblazer signs shall be capable of displaying static and flashing arrows.	4.4.3	Same as High Level Requirement		
				4.4.6	Trailblazer signs shall have a dynamic arrow capable of showing multiple directions either singly or concurrently.	4.4.4	Same as High Level Requirement		
						4.4.5	Trailblazer signs shall be uniquely identifiable		
						4.4.6	Turn prohibition signs shall be blankout signs		
		5.3.2	Signs shall be clearly distinguishable from other signage.			4.4.5	Trailblazer signs shall be uniquely identifiable		
3.1.4	Proactively manage diverted traffic to minimize local congestion	5.1.2	The System shall deploy ITS field elements to support the following functions: Traffic control Motorist information Traffic monitoring	4.1.1	The System shall be able to collect and display data to support the following functions at local and interjurisdictional levels: Traffic Operations, Recurrent Congestion Management, Non-recurrent Congestion/Incident Management, Special Event Management, Seasonal Traffic Management, Emergency/Disaster Management	4.1.1	Same as High Level Requirement		
		5.2.2	The Subsystem shall be capable of controlling and monitoring the operation of traffic signal equipment at selected intersections.	4.1.26	The System shall be capable of being controlled and monitored from local TMCs, the SMCTMS and the D4TMC	4.1.51	The System shall have a standalone interface for a user in the D4TMC until such time as the System is integrated into the D4ATMS at which time the interface shall be transparent to the user in the D4TMC		
						4.4.9	The Subsystem shall allow sign messages to be centrally validated.		
				4.3.1	Controllers shall be capable of operating under the following modes: time of day, traffic responsive, manual, flash, and free actuated.	4.3.1	Same as High Level Requirement		
						4.3.5	Controllers shall be capable of storing at least 32 unique signal timing plans		
				4.3.2	Controllers shall be able to receive and implement timing plans from the System that alter the following parameters: splits, cycle lengths, green extensions,	4.3.2	Same as High Level Requirement		

TRACEABILITY MATRIX-SAN MATEO COUNTY SMART CORRIDORS PROGRAM-SYSTEM ENGINEERING

ConOps Reference Section	ConOps Description	Functional Requirements Section	Functional Requirements Description	High Level Requirements Reference Section	High Level Requirements Description	Detailed Design Requirements Reference Section	Detailed Design Requirements Description	Test Procedure	Comments
					offsets, lead/lag, and recalls.				
		5.3.3	Signage shall be used to help manage the surface transportation system	4.4.1	The Directional Sign Subsystem shall be composed of signs noting the direction of travel (trailblazers) and signs prohibiting specified directions of travel.	4.4.1	Same as High Level Requirement		
						4.4.5	Trailblazer signs shall be uniquely identifiable		
				4.4.7	Signs shall conform to the Manual of Uniform Traffic Control Devices standards.	4.4.8	Sign placement shall conform to the MUTCD		
						4.4.16	Turn prohibition signs shall comply with MUTCD		
				4.5.7	Each ADMS shall display 2 lines of text with 12 12-inch high characters per line.	4.5.10	Each ADMS shall display 2 lines of text with 12 12-inch high characters per line.		
				4.5.1	Dynamic Message Signs within local jurisdictions shall be designed to meet local agency standards.	4.1.40	*The System shall support compliance with all interagency agreements.*		
		5.3.4	Enroute traveler information shall be provided to the motorist.	4.5.2	The Subsystem shall allow sign messages to be centrally validated.	4.5.1	Same as High Level Requirement		
						4.5.8	The user shall be able to view a message before it is transmitted (WYSIWYG)		
				4.5.4	The System shall be capable of displaying messages for different lengths of time.	4.5.4	The Subsystem shall be capable of displaying messages on a scheduled basis…		
						4.5.5	The Subsystem shall be capable of displaying messages for a user-settable length of time		
				4.5.5	The Subsystem shall be able to display multiple messages.	4.5.9	The Subsystem shall be capable of displaying either a 1- or 2-phase message		
		5.4.3	Data from the monitoring system shall be transmitted to the TMC for analysis within the traffic control system.	4.1.5	The System shall conform to current Caltrans policies, practices and standards.	4.1.7	The System shall conform to current Caltrans policies, practices and standards, including:		
						4.1.8	All field equipment shall meet the environmental requirements of the above noted Caltrans policies, practices and standards		

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ConOps Reference Section	ConOps Description	Functional Requirements Section	Functional Requirements Description	High Level Requirements Reference Section	High Level Requirements Description	Detailed Design Requirements Reference Section	Detailed Design Requirements Description	Test Procedure	Comments
						4.1.55	The delivered and installed System shall be fully documented. This documentation shall consist of pertinent technical documentation and user documentation sufficient to maintain and operate the System.		
						4.3.7	Controllers shall meet either NEMA TS2, or be compatible with Model 2070 or Model 2070 Lite requirements in the TEES		
				4.1.21	Data shall be based on a common geographic reference.	4.1.34	Data shall be geographically referenced on the NAD 83 (NAVD 88) California Coordinate System.		
						4.2.4	The map shall be GIS based using standard GIS files to render a geographically accurate, to-scale map		
3.1.5	Integrate SM Smart Corridors via the Bay Area Center-to-Center Network	5.5.2	Provide capability for center to center (C2C) communications.	4.1.3	The System shall provide compatibility with the Bay Area C2C Interface Control Document	4.1.4	Same as High Level Requirement		
3.1.6	Provide for remote monitoring of local street traffic flow through the use of video cameras	5.4.1	Surveillance shall be used to view the surface transportation system.	4.6.1	The Subsystem shall support the video monitoring of selected arterial locations and midblock locations to provide information regarding traffic conditions.	4.6.1	Same as High Level Requirement		
						4.6.4	The user shall be able to select and view any CCTV camera in the Subsystem		
						4.6.5	CCTV images from all cameras shall be viewable sequentially, individually, or simultaneously as a group		
						4.6.7	The Subsystem shall support both PTZ and fixed cameras		
				4.6.2	Each CCTV camera shall transmit a color image.	4.6.2	Same as High Level Requirement		
				4.6.3	Camera images shall conform to NTSC standards.	4.6.3	Same as High Level Requirement		
				4.6.5	All video shall be a minimum of 10 frames per second.	4.6.6	Same as High Level Requirement		

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ConOps Reference Section	ConOps Description	Functional Requirements Section	Functional Requirements Description	High Level Requirements Reference Section	High Level Requirements Description	Detailed Design Requirements Reference Section	Detailed Design Requirements Description	Test Procedure	Comments
				4.8.3	The Subsystem shall support all existing and future video and data bandwidth requirements.	4.8.1	The Communication Subsystem shall be able to incrementally increase or decrease in size with limited cost and risk as the need to add or remove equipment becomes necessary. A design utilizing modular communication equipment shall be provided		
						4.8.7	New backbone fiber optic cable shall be a minimum of 72 single-mode fibers		
						4.8.8	New spur (drop) fiber optic cable shall be sized for the application		
						4.8.13	The communications network shall provide sufficient bandwidth and network configuration to support full motion video up to 30 frames per second		
		5.4.2	The Subsystem shall support the monitoring of traffic at selected locations.	4.1.19	The System shall be capable of collecting and displaying the following information: data on intersection operation, volume, occupancy, and speed, CCTV images, CMS and directional sign information, historical detector and signal timing data, maintenance information.	4.1.29	The System shall be capable of collecting and displaying the following information: Maintenance information which can be displayed or printed by device type, location, and time of day/date.		
						4.1.30	The CCTV cameras shall be capable of being placed in at least four independent camera tours per workstation		
						4.1.33	The primary GUI shall be an interactive map that displays the current status of the roadway network and ITS field elements		
						4.3.4	The Subsystem shall have the capability to export signal timing plan data		
						4.9.1	All video images from CCTV cameras located within the project shall be accessible to any jurisdiction or local		

TRACEABILITY MATRIX-SAN MATEO COUNTY SMART CORRIDORS PROGRAM-SYSTEM ENGINEERING

ConOps Reference Section	ConOps Description	Functional Requirements Section	Functional Requirements Description	High Level Requirements Reference Section	High Level Requirements Description	Detailed Design Requirements Reference Section	Detailed Design Requirements Description	Test Procedure	Comments
							agency throughout the corridor on any remote computer attached to the network.		
3.1.7	Maximize green phasing along alternate routes	5.2.2	The Subsystem shall be capable of controlling and monitoring the operation of traffic signal equipment at selected intersections.	4.1.26	The System shall be capable of being controlled and monitored from local TMCs, the SMCTMS and the D4TMC	4.1.51	The System shall have a standalone interface for a user in the D4TMC until such time as the System is integrated into the D4ATMS at which time the interface shall be transparent to the user in the D4TMC		
						4.3.3	The Subsystem shall provide processing of emergency vehicle preemption		
						4.4.9	The Subsystem shall allow sign messages to be centrally validated.		
				4.3.1	Controllers shall be capable of operating under the following modes: time of day, traffic responsive, manual, flash, and free actuated.	4.3.1	Same as High Level Requirement		
						4.3.5	Controllers shall be capable of storing at least 32 unique signal timing plans		
				4.3.2	Controllers shall be able to receive and implement timing plans from the System that alter the following parameters: splits, cycle lengths, green extensions, offsets, lead/lag, and recalls.	4.3.2	Same as High Level Requirement		
						4.2.5	The Subsystem shall provide authorized users the capability to view the following signalized intersection information:		
3.1.8	Provide local site for monitoring and operations	5.1.4	The System shall support operation by multiple concurrent users/operators	4.1.16	The System shall support the ability for multiple users to monitor the same data item.	4.1.38	The System shall have the ability to create reports containing current and historical data. *The System shall support the ability for multiple users to monitor the same data items*		
				4.1.18	The System shall allow each Agency to exercise full control over ITS elements owned by that Agency.	4.1.28	During normal operations, each Agency shall have primary privileges over field elements in their own jurisdiction		

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ConOps Reference Section	ConOps Description	Functional Requirements Section	Functional Requirements Description	High Level Requirements Reference Section	High Level Requirements Description	Detailed Design Requirements Reference Section	Detailed Design Requirements Description	Test Procedure	Comments
				4.1.23	The System shall support authorized user access via the internet	4.1.25	Users shall be able to access the System via the Internet with the same privileges as if they were on a System workstation		
						4.2.3	The application shall launch and operate within a web browser and shall not utilize any 3rd party remote web access, web application delivery or virtual networking tools to achieve/simulate a web application.		
				4.1.25	The System shall support compliance with all interagency agreements.	4.1.40	Same as High Level Requirement		
				4.5.6	Remote users shall be able to monitor messages.	4.1.27	Depending on their access level, users shall be able to perform the following actions:		
		5.1.5	The System shall support non-incident operation by multiple jurisdictions	4.1.18	The System shall allow each Agency to exercise full control over ITS elements owned by that Agency.	4.1.28	During normal operations, each Agency shall have primary privileges over field elements in their own jurisdiction		
3.1.9	Provide a Hub in San Mateo County for central monitoring and management of traffic on local streets and as a backup to the D4TMC	5.1.4	The System shall support operation by multiple concurrent users/operators	4.1.16	The System shall support the ability for multiple users to monitor the same data item.	4.1.38	The System shall have the ability to create reports containing current and historical data. *The System shall support the ability for multiple users to monitor the same data items*		
				4.1.18	The System shall allow each Agency to exercise full control over ITS elements owned by that Agency.	4.1.28	During normal operations, each Agency shall have primary privileges over field elements in their own jurisdiction		
				4.1.20	The SMCHub shall serve as the central local control point of the Smart Corridor and serve as back-up for Caltrans D4TMC operations.	4.1.31	The SMCHub shall normally control and monitor the local field devices that are not owned by Caltrans.		
						4.1.32	The SMCHub shall take over for Caltrans in the event the Caltrans D4 TMC becomes unavailable. Caltrans shall be able to operate the system through a leased line to the		

TRACEABILITY MATRIX-SAN MATEO COUNTY SMART CORRIDORS PROGRAM-SYSTEM ENGINEERING

ConOps Reference Section	ConOps Description	Functional Requirements Section	Functional Requirements Description	High Level Requirements Reference Section	High Level Requirements Description	Detailed Design Requirements Reference Section	Detailed Design Requirements Description	Test Procedure	Comments
							SMCHub.		
				4.1.23	The System shall support authorized user access via the internet	4.1.25	Users shall be able to access the System via the Internet with the same privileges as if they were on a System workstation		
						4.2.3	The application shall launch and operate within a web browser and shall not utilize any 3rd party remote web access, web application delivery or virtual networking tools to achieve/simulate a web application.		
				4.1.25	The System shall support compliance with all interagency agreements.	4.1.40	Same as High Level Requirement		
				4.8.8	The Subsystem shall include a SONET node at the SMCHub to connect to the existing Caltrans SONET backbone network.	4.8.4.3	The Communications Subsystem shall support interconnect and coordination between local agency traffic signal systems on local streets (local TMCs/TOCs), the SMCHub and State operated traffic signals on State routes (D4TMC).		
						4.8.5	The Communications Subsystem shall provide capability for center-to-center (C2C) communications between the proposed SMCHub and the D4TMC.		
		5.1.5	The System shall support non-incident operation by multiple jurisdictions	4.1.18	The System shall allow each Agency to exercise full control over ITS elements owned by that Agency.	4.1.28	During normal operations, each Agency shall have primary privileges over field elements in their own jurisdiction		
3.2	**Arterial Management**								
3.2.1	Implement traffic responsive and time of day signal timing from a remote location	5.2.2	The Subsystem shall be capable of controlling and monitoring the operation of traffic signal equipment at selected intersections.	4.1.26	The System shall be capable of being controlled and monitored from local TMCs, the SMCTMS and the D4TMC	4.1.51	The System shall have a standalone interface for a user in the D4TMC until such time as the System is integrated into the D4ATMS at which time the interface shall be transparent to the user in the D4TMC		

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						4.4.9	The Subsystem shall allow sign messages to be centrally validated.		
				4.3.1	Controllers shall be capable of operating under the following modes: time of day, traffic responsive, manual, flash, and free actuated.	4.3.1	Same as High Level Requirement		
						4.3.5	Controllers shall be capable of storing at least 32 unique signal timing plans		
				4.3.2	Controllers shall be able to receive and implement timing plans from the System that alter the following parameters: splits, cycle lengths, green extensions, offsets, lead/lag, and recalls.	4.3.2	Same as High Level Requirement		
3.2.2	Maximize green phasing along major corridors	5.2.2	The Subsystem shall be capable of controlling and monitoring the operation of traffic signal equipment at selected intersections.	4.1.26	The System shall be capable of being controlled and monitored from local TMCs, the SMCTMS and the D4TMC	4.1.51	The System shall have a standalone interface for a user in the D4TMC until such time as the System is integrated into the D4ATMS at which time the interface shall be transparent to the user in the D4TMC		
						4.4.9	The Subsystem shall allow sign messages to be centrally validated.		
				4.3.1	Controllers shall be capable of operating under the following modes: time of day, traffic responsive, manual, flash, and free actuated.	4.3.1	Same as High Level Requirement		
						4.3.5	Controllers shall be capable of storing at least 32 unique signal timing plans		
				4.3.2	Controllers shall be able to receive and implement timing plans from the System that alter the following parameters: splits, cycle lengths, green extensions, offsets.	4.3.2	Same as High Level Requirement		
3.2.3	Upgrade controllers and communications infrastructure	5.1.3	The System shall be capable of interfacing with existing and planned ITS elements at all TMC levels.	4.1.2	The System shall work with different makes and models of equipment intended for the same purpose.	4.1.3	Same as High Level Requirement		
						4.1.5	The System shall implement only published standards with any amendments to be approved by Caltrans		

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						4.1.6	Standards shall include the following industry standards groups as applicable at a minimum:		
						4.1.54	The System shall be vendor- and model-independent		
				4.8.7	The Subsystem shall be able to interface and integrate with the proposed Caltrans ATMS.	4.1.51	The System shall have a standalone interface for a user in the D4TMC until such time as the System is integrated into the D4ATMS at which time the interface shall be transparent to the user in the D4TMC		
		5.5.1	Provide capability for center-to-field (C2F) communications.		Requirement was deleted as the interface may be NTCIP and/or proprietary (modified in DDR)	4.1.6.2	NTCIP – Center-to-Field as indicated in the San Mateo Smart Corridor Program Interface Control Document (ICD), dated July 2009.		
3.2.4	Improve data collection of real-time travel conditions through system detection. Dissemination of real-time travel conditions is a possible future enhancement.	5.4.2	The Subsystem shall support the monitoring of traffic at selected locations.	4.1.19	The System shall be capable of collecting and displaying the following information: data on intersection operation, volume, occupancy, and speed, CCTV images, CMS and directional sign information, historical detector and signal timing data, maintenance information.	4.1.29	The System shall be capable of collecting and displaying the following information: Maintenance information which can be displayed or printed by device type, location, and time of day/date.		
						4.1.30	The CCTV cameras shall be capable of being placed in at least four independent camera tours per workstation		
						4.1.33	The primary GUI shall be an interactive map that displays the current status of the roadway network and ITS field elements		
						4.3.4	The Subsystem shall have the capability to export signal timing plan data		
						4.9.1	All video images from CCTV cameras located within the project shall be accessible to any jurisdiction or local agency throughout the corridor on any remote computer attached to the		

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							network.		
				4.7.1	The Subsystem shall provide for measurement of traffic parameters at selected locations.	4.7.1	The Subsystem shall provide for measurement of speed, volume, and occupancy on a per lane basis at selected locations		
						4.7.2	The Subsystem shall provide volume, speed, occupancy, and status data which can be displayed or printed by time period, location, lane, station and group		
						4.7.3	The Subsystem shall collect data at a minimum data accumulation period of once every 30 seconds		
						4.7.5	The Subsystem shall provide historical detector data which can be displayed or printed by time of day, interval, location, and group		
				4.7.2	The Subsystem shall report data at a minimum of once per cycle length.	4.7.4	After the end of each data accumulation period, the data for that time period shall be made available to the System.		
3.2.5	Enable remote monitoring of real-time travel conditions	5.2.1	The Subsystem shall collect and maintain all data required for monitoring and displaying traffic information from selected intersections.	4.1.22	The System shall have the ability to create reports.	4.1.37	The user shall be able to specify the format of reports and the data to be included in these reports		
						4.1.38	The System shall have the ability to create reports containing current and historical data		
						4.2.13	The Subsystem shall provide data on intersection operation including timing plans and intersection status which can be displayed or printed by intersection name or intersection number		

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						4.2.14	The Subsystem shall provide historical signal timing data which can be displayed or printed by time-of-day, interval, location, and group		
				4.8.1	The Communications Subsystem shall be capable of supporting a combination of fiber, wireless, and copper media.	4.8.2	Same as High Level Requirement		
						4.8.11	Any wireless communications providing access to and control of multiple ITS devices or creating a link to multiple wireless devices shall be considered to be part of the communications backbone		
				4.8.2	The Subsystem shall include concentrators at selected locations along the corridor to aggregate communications network data from ITS field devices and provide transport to the System.	4.8.4.2	Provide direct Ethernet communications between the HUBs and the SMCHub.		
						4.8.6	*The SMCHub shall serve as the central local control point of the Smart Corridor and serve as back-up for Caltrans D4TMC operations.*		
						4.10.1	The connection between the local agency TMCs (if they exist) and each other as well as their connection to the D4TMC shall be through the SMCHub.		
		5.1.7	The System shall be capable of collecting, displaying and sharing information.	4.2.3	The Subsystem shall allow coordination across jurisdictional boundaries.	4.2.8	The Subsystem shall allow groups of controllers to be created and controlled independent of jurisdictional boundaries		
						4.2.9	Same as High Level Requirement		
		5.1.9	The System shall be secure.	4.1.17	The System shall have security and access control systems to prevent any unauthorized user from accessing the System.	4.1.21	Each user account shall be unique		
						4.1.24	Users connected to the network and using a password and user		

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							identification shall be considered an authorized user		
						4.1.35	All actions taken by users shall be logged with the time, date, user identification, and action taken		
						4.6.11	Each video image shall have a unique identification which can be modified by a user with a suitable access level.		
						4.8.25	The Subsystem shall provide the following security measures at a minimum:		
				4.2.1	The Subsystem shall support security measures that protect the hierarchy of users.	4.8.25.2	Computer workstations shall include user passwords and administrative privileges supporting different levels of control prioritization as approved by Caltrans.		
3.2.6	Integrate traffic signals across jurisdictions	5.2.2	The Subsystem shall be capable of controlling and monitoring the operation of traffic signal equipment at selected intersections.	4.1.26	The System shall be capable of being controlled and monitored from local TMCs, the SMCTMS and the D4TMC	4.1.51	The System shall have a standalone interface for a user in the D4TMC until such time as the System is integrated into the D4ATMS at which time the interface shall be transparent to the user in the D4TMC		
						4.4.9	The Subsystem shall allow sign messages to be centrally validated.		
				4.3.1	Controllers shall be capable of operating under the following modes: time of day, traffic responsive, manual, flash, and free actuated.	4.3.1	Same as High Level Requirement		
						4.3.5	Controllers shall be capable of storing at least 32 unique signal timing plans		
				4.3.2	Controllers shall be able to receive and implement timing plans from the System that alter the following parameters: splits, cycle lengths, green extensions, offsets, lead/lag, and recalls.	4.3.2	Same as High Level Requirement		

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3.2.7	Improve traffic management for normal traffic operations	5.1.5	The System shall support non-incident operation by multiple jurisdictions.	4.1.18	The System shall allow each Agency to exercise full control over ITS elements owned by that Agency.	4.1.28	During normal operations, each Agency shall have primary privileges over field elements in their own jurisdiction		
		5.1.1	The System shall be able to collect and display data to support traffic management.	4.1.21	Data shall be based on a common geographic reference.	4.1.34	Data shall be geographically referenced on the NAD 83 (NAVD 88) California Coordinate System.		
						4.2.4	The map shall be GIS based using standard GIS files to render a geographically accurate, to-scale map		
				4.1.33	Within the System, the various components shall be time synchronized.	4.1.46	The System shall synchronize clocks with all field devices using Pacific Standard Time.		
						4.2.11	The Subsystem shall utilize a common system time reference, and clocks shall be synchronized at least once every hour		
				4.2.2	Within a jurisdiction, the Subsystem shall be capable of the following modes of operation on a system-wide basis, a group basis, or as individual intersections: time of day operation, traffic responsive operation, manual operation, flash operation, free actuated operation.	4.2.1	Same as High Level Requirement		
						4.2.2	Traffic responsive operation shall be based on a combination of occupancy and volume data from system detectors		
						4.2.6	The Subsystem shall provide authorized users the capability to alter signal controller parameters listed in DDR 4.3.2		
						4.2.7	The Subsystem shall be capable of restricting the alteration of signal controller parameters listed in DDR 4.3.3		

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						4.2.10	Users can assign intersections to groups on a time of day basis and on a traffic responsive basis		
						4.2.12	Authorized users shall be able to select the Subsystem's mode of operation at any time		
						4.2.15	Once an operating mode is selected, the Subsystem shall begin implementation of selected mode within one cycle length		
				4.7.1	The Subsystem shall provide for detection of vehicles at selected locations.	4.7.1	The Subsystem shall provide for measurement of speed, volume, and occupancy on a per lane basis at selected locations		
						4.7.2	The Subsystem shall provide volume, speed, occupancy, and status data which can be displayed or printed by time period, location, lane, station and group		
						4.7.3	The Subsystem shall collect data at a minimum data accumulation period of once every 30 seconds		
						4.7.5	The Subsystem shall provide historical detector data which can be displayed or printed by time of day, interval, location, and group		
				4.7.2	The Subsystem shall report data at a minimum of once per cycle length.	4.7.4	After the end of each data accumulation period, the data for that time period shall be made available to the System.		
3.2.8	Maintain functionality of existing legacy systems	5.1.3	The System shall be capable of interfacing with existing and planned ITS elements at all TMC levels.	4.1.2	The System shall work with different makes and models of equipment intended for the same purpose.	4.1.3	Same as High Level Requirement		
						4.1.5	The System shall implement only published standards with any		

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							amendments to be approved by Caltrans		
						4.1.6	Standards shall include the following industry standards groups as applicable at a minimum:		
						4.1.54	The System shall be vendor- and model-independent		
				4.1.9	The System shall be capable of interfacing with existing and planned ITS elements at the local and regional levels.	4.1.13	At the local level, the System shall be capable of interfacing with existing fiber networks and System-compatible controllers		
						4.1.14	At the regional level, the System shall be capable of interfacing with the existing BART fiber backbone and with the D4TMC ATMS		
						4.1.49	Proprietary protocols shall be used only when necessary to communicate to existing devices that do not support NTCIP communications protocols		
						4.7.6	The System shall be capable of interfacing with all legacy vehicle detector sensors		
						4.8.21	ITS devices requiring different transmission speeds and communication protocols shall be capable of coexisting on the same communication channel		
						4.8.22	The same type of ITS device from multiple manufacturers shall be capable of operating on the same communications channel		
						4.8.23	Multiple types of ITS devices from multiple manufacturers shall operate on the same communications channel		
				4.8.7	The Subsystem shall be able to interface	4.1.51	The System shall have a		

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					and integrate with the proposed Caltrans ATMS.		standalone interface for a user in the D4TMC until such time as the System is integrated into the D4ATMS at which time the interface shall be transparent to the user in the D4TMC		
3.3	**Traveler Information**								
3.3.1	Provide travel times on local streets by using system detection or other technology	Future							
3.3.2	Use C2C between the System and Caltrans	5.5.2	Provide capability for center to center (C2C) communications.	4.1.3	The System shall provide compatibility with the Bay Area C2C Interface Control Document	4.1.4	Same as High Level Requirement		
		5.1.12	The System as a whole and each Subsystem should support industry standards to allow multiple types of field equipment from multiple manufacturers to operate as an integrated system.	4.1.2	The System shall work with different makes and models of equipment intended for the same purpose.	4.1.3	Same as High Level Requirement		
						4.1.5	The System shall implement only published standards with any amendments to be approved by Caltrans		
						4.1.6	Standards shall include the following industry standards groups as applicable at a minimum:		
						4.1.54	The System shall be vendor- and model-independent		
				4.1.4	Field elements shall be NTCIP compliant.	4.5.12	The Subsystem shall support NTCIP 1203 (Ver. 2.35a Published 2007)		
				4.1.33	Within the System, the various components shall be time synchronized.	4.1.46	The System shall synchronize clocks with all field devices using Pacific Standard Time.		
						4.2.11	The Subsystem shall utilize a common system time reference, and clocks shall be synchronized at least once every hour		
				4.8.5	The Subsystem shall support industry standards.	4.8.3	The Communication Subsystem shall support serial and Ethernet-based communications.		
						4.8.4	The Communications Subsystem shall provide		

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							capability for center-to-field communications connecting and supporting all ITS elements…with the SMCHub and the D4TMC		
						4.8.5	The Communications Subsystem shall provide capability for center-to-center communications between the SMCHub and the D4TMC		
						4.8.9	Communications equipment shall include Ethernet switches.		
						4.8.10	All field Ethernet switches shall support, at a minimum:		
						4.8.12	All design of wireless links shall include a full path analysis as required		
						4.8.14	All communications field equipment shall be hardened complying with the NEMA TS1 and TS2 Environmental Requirements for traffic control equipment. Where there is a conflict with other requirements, the more stringent requirement shall apply		
						4.8.24	The communication equipment specified in the design shall demonstrate technology maturity through successful operations and integration with other established and working systems		
3.3.3	Integrate with Bay Area 511 (future)	Through Caltrans							
3.4	**Transit Management**								
3.4.1	Implement transit signal priority	Future							
3.4.2	Disseminate transit travel times	Future							

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3.4.3	Provide advance warning and clearance of at-grade crossings.	Future							
3.4.4	Utilize transit GPS to acquire travel time information	Future							
3.5	**System Operations and Maintenance**								
3.5.1	Clear notation of which agency owns and operates each element	5.1.10	All field and TMC equipment shall be readily accessible in a safe manner for maintenance.	4.1.30	A demarcation point shall be established for defining the limits of maintenance responsibility for communication lines, all field equipment and all TMC equipment.	4.1.44	Through the use of external cabinets or by having equipment in separate cabinets, it shall be possible to establish a demarcation point for defining the limits of maintenance responsibility for communication lines, all field equipment and all TMC equipment		
						4.8.17	The communications network and associated equipment shall be readily and safely accessible for maintenance.		
		5.1.16	The System shall be designed to delineate maintenance responsibility.	4.1.25	The System shall support compliance with all interagency agreements.	4.1.40	Same as High Level Requirement		
				4.1.30	A demarcation point shall be established for defining the limits of maintenance responsibility for communication lines, all field equipment and all TMC equipment.	4.1.44	Through the use of external cabinets or by having equipment in separate cabinets, it shall be possible to establish a demarcation point for defining the limits of maintenance responsibility for communication lines, all field equipment and all TMC equipment		
						4.8.17	The communications network and associated equipment shall be readily and safely accessible for maintenance.		
				4.4.4	The Subsystem shall be able to report the status of all sign hardware.	4.4.7	Same as High Level Requirement		
						4.4.10	Users shall have the capability to poll a		

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							directional sign to view current sign displays, equipment status, and to test communications		
						4.4.11	The Subsystem shall be able to automatically report the status of all internal electronic components, and communication equipment		
				4.5.3	The Subsystem shall be able to report the status of all sign hardware.	4.5.2	Users shall have the capability to manually poll an ADMS to view/confirm current sign messages, equipment status, sign temperature and to test communications		
						4.5.3	The Subsystem shall be able to automatically report the status of all sign hardware including:		
3.5.2	Utilize technology that will not require substantial software development. Provide device status and failure notification	5.1.11	The System as a whole and each Subsystem shall maximize use of commercial off the shelf (COTS) software and hardware products and applications.	4.1.2	The System shall work with different makes and models of equipment intended for the same purpose.	4.1.3	Same as High Level Requirement		
						4.1.5	The System shall implement only published standards with any amendments to be approved by Caltrans		
						4.1.6	Standards shall include the following industry standards groups as applicable at a minimum:		
						4.1.54	The System shall be vendor- and model-independent		
3.5.3	Not dependent on other systems for operability	5.1.14	The System and each Subsystem shall have high availability.	4.1.6	Software and hardware shall be reliable. Reliability shall be measured by the following methods: Mean time between failure, percentage of time that the System is functioning, number of times the System or any Subsystem stop functioning within a given time period, Amount of time required for the System to resume normal functions after a power failure or other ITS element failure.	4.1.53	The System shall demonstrate three different examples of successful operations and integration with other established and similar systems		

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						4.1.56	Software and hardware shall be reliable. Reliability shall be measured by the following methods:		
						4.1.57	System performance measures shall be based on reliability measures and on the following:		
						4.3.6	Controllers shall continue to operate normally during all communication polling and database transfers		
						4.8.15	All communications field equipment shall be protected and able to maintain normal operations under local adverse roadway conditions		
						4.8.19	The Subsystem shall provide a network management system with the following minimum features:		
				4.1.8	The System shall include alarms to notify operators and maintenance personnel of System and device failures.	4.1.10	Alarms shall be provided for the following conditions:		
						4.1.11	Alarms shall be user-settable		
				4.1.24	The System shall be standalone.	4.1.39	The System shall not require input from other systems to function		
				4.1.27	The System, each Subsystem and the associated field equipment shall allow unattended operation.	4.4.13	The Subsystem shall be capable of displaying messages on a scheduled basis with the start/end times established by the user		
						4.4.14	The Subsystem shall be capable of displaying messages for a user-settable length of time		
				4.1.28	Each Subsystem shall be able to perform the same functions as a standalone system that it will perform within the integrated system.	4.1.42	Same as High Level Requirement		
						4.7.7	System detectors shall collect/calculate volume, occupancy, and speed		

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							data independent of local signal controller actuation and detection functions		
				4.8.4	The Subsystem shall provide communications network redundancy.				
3.5.4	All Caltrans elements operate during power outages using back-up power sources	5.1.13	The System each Subsystem and the associated field equipment shall have a fail safe mode.	4.1.7	The System and each Subsystem shall have predetermined methods of operation during power failures or other ITS element failures.	4.1.9	System design shall provide backup capabilities to allow continuation of a satisfactory level of coordinated operation should a … failure occur. A failure…shall trigger corrective action to related adjacent intersections		
						4.1.10	*The System shall include alarms to notify operators and maintenance personnel of System and device failures.* Alarms shall be provided for the following conditions:		
						4.1.11	Alarms shall be user-settable		
						4.1.12	It shall be possible to establish threshold levels for determining if a device or function has failed.		
						4.1.41	Subsystems shall continue to operate with the same functions in the event that other Subsystems are not available		
						4.1.42	Each Subsystem shall be able to perform the same functions as a standalone system that it will perform within the integrated System.		
						4.1.43	In the event of a power failure at the D4TMC, the SMCHub, the local TMC's, or at the field elements, the affected System/Subsystem/field element shall revert to the power backup available locally.		

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						4.4.13	The sign controller shall be able to retain user and scheduled plan commands in the event of a sign failure or loss of communication to a sign and…		
						4.5.11	The sign controller shall be able to retain commands in the event of a sign failure or…		
						4.8.18	Diagnostics shall be provided via visual displays on the equipment or output to a port connected to a laptop.		
				4.1.29	The System and all field elements shall be protected against power outages.	4.1.43	In the event of a power failure at the D4TMC, the SMCHub, the local TMCs, or at the field elements, the affected System/Subsystem/Field element shall revert to the power backup available locally		
						4.8.20	The Subsystem shall include back-up power systems for communications network equipment for directional signs, hubs and traffic signals in all field cabinets, HUBs, and TMCs and other designated facilities. Run-time shall be determined during design.		
				4.2.4	In the event of a loss of communications to a Subsystem being controlled at the SMCHub or D4TMC level, the Traffic Control Subsystem shall revert to local agency control.	4.2.16	In the event of a loss of communications to a Subsystem being controlled at the SMCHub or D4TMC, the Traffic Control Subsystem shall revert to local control/time-of-day schedules		
5.2	**Operational Strategies**								
5.2.1	Under normal operations, each agency will be responsible for operating their	5.1.5	The System shall support non-incident operation by multiple jurisdictions.	4.1.18	The System shall allow each Agency to exercise full control over ITS elements owned by that Agency.	4.1.28	During normal operations, each Agency shall have primary privileges over		

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	own equipment						field elements in their own jurisdiction		
5.2.2	SMCHub will serve as local agency control point during normal operations and as backup for the Caltrans TMC	5.1.4	The System shall support operation by multiple concurrent users/operators	4.1.16	The System shall support the ability for multiple users to monitor the same data item.	4.1.38	*The System shall have the ability to create reports* containing current and historical data. *The System shall support the ability for multiple users to monitor the same data items.*		
				4.1.18	The System shall allow each Agency to exercise full control over ITS elements owned by that Agency.	4.1.28	During normal operations, each Agency shall have primary privileges over field elements in their own jurisdiction		
				4.1.23	The System shall support authorized user access via the internet	4.1.25	Users shall be able to access the System via the Internet with the same privileges as if they were on a System workstation		
						4.2.3	The application shall launch and operate within a web browser and shall not utilize any 3rd party remote web access, web application delivery or virtual networking tools to achieve/simulate a web application.		
				4.1.25	The System shall support compliance with all interagency agreements.	4.1.40	Same as High Level Requirement		
				4.8.6	The SMCHub shall serve as the central local control point of the Smart Corridor and serve as back-up for Caltrans D4TMC operations.	4.8.6	Same as High Level Requirement		
						4.10.1	The connection between the local agency TMCs (if they exist) and each other as well as their connection to the D4TMC shall be through the SMCHub		
		5.1.6	The System shall allow a hierarchy of users.	4.1.12	The System shall allow a hierarchy of users with the following privileges: Administrative, Primary, Secondary, & Tertiary	4.1.20	The number of users allowed to be defined in the System shall be as follows and in the level of decreasing authority:		
						4.1.22	Where users of the same level are attempting to perform the same function, the user who		

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							initiated the action first shall have priority		
						4.1.23	Where a user is overridden by another user, he/she shall receive a notification of this action		
				4.1.13	Administrative users shall have the ability to add/modify/delete users	4.1.20.1.1	*Administrative users shall have the ability to add/modify/delete users* to specific user levels and within that level to specify what they can or cannot do.		
				4.1.14	Administrative users shall have the ability to assign command-specific access to specific users.	4.1.20.1.1	*Administrative users shall have the ability to add/modify/delete users* to specific user levels and within that level to specify what they can or cannot do.		
				4.1.15	Users shall be able to control and operate the System if they have the proper privileges. Other users shall be able to monitor the available information from the field elements.	4.1.26	A manual command shall override a system command		
						4.1.27	Depending on their access level, users shall be able to perform the following actions:		
						4.1.36	The System shall provide a user with spell check, text wrapping, and copy/cut/paste capabilities on reports and sign messages.		
						4.6.12	The capability shall exist to share control of cameras among agencies within the corridor including Caltrans		
				4.6.6	If there is a conflict between secondary users, viewing priority shall be assignable on a first-come first-served basis.	4.1.22	Where users of the same level are attempting to perform the same function, the user who initiated the action first shall have priority.		
5.2.3	Cameras will be accessible for control and viewing by all agencies	5.1.4	The System shall support operation by multiple concurrent users/operators	4.1.16	The System shall support the ability for multiple users to monitor the same data item.	4.1.38	*The System shall have the ability to create reports* containing current and historical		

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							data. *The System shall support the ability for multiple users to monitor the same data items.*		
				4.1.18	The System shall allow each Agency to exercise full control over ITS elements owned by that Agency.	4.1.28	During normal operations, each Agency shall have primary privileges over field elements in their own jurisdiction		
				4.1.23	The System shall support authorized user access via the internet	4.1.25	Users shall be able to access the System via the Internet with the same privileges as if they were on a System workstation		
						4.2.3	The application shall launch and operate within a web browser and shall not utilize any 3rd party remote web access, web application delivery or virtual networking tools to achieve/simulate a web application.		
				4.1.25	The System shall support compliance with all interagency agreements.	4.1.40	Same as High Level Requirement		
5.2.3	A control hierarchy will be established	5.1.6	The System shall allow a hierarchy of users.	4.1.12	The System shall allow a hierarchy of users with the following privileges: Administrative, Primary, Secondary, & Tertiary	4.1.20	The number of users allowed to be defined in the System shall be as follows and in the level of decreasing authority:		
						4.1.22	Where users of the same level are attempting to perform the same function, the user who initiated the action first shall have priority		
						4.1.23	Where a user is overridden by another user, he/she shall receive a notification of this action		
				4.1.13	Administrative users shall have the ability to add/modify/delete users	4.1.20.1.1	*Administrative users shall have the ability to add/modify/delete users* to specific user levels and within that level to specify what they can or cannot do.		
				4.1.14	Administrative users shall have the ability to assign command-specific access to specific users.	4.1.20.1.1	*Administrative users shall have the ability to add/modify/delete users*		

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							to specific user levels and within that level to specify what they can or cannot do.		
				4.1.15	Users shall be able to control and operate the System if they have the proper privileges. Other users shall be able to monitor the available information from the field elements.	4.1.26	A manual command shall override a system command		
						4.1.27	Depending on their access level, users shall be able to perform the following actions:		
						4.1.36	The System shall provide a user with spell check, text wrapping, and copy/cut/paste capabilities		
						4.6.12	The capability shall exist to share control of cameras among agencies within the corridor including Caltrans		
				4.6.6	If there is a conflict between secondary users, viewing priority shall be assignable on a first-come first-served basis.	4.1.22	Where users of the same level are attempting to perform the same function, the user who initiated the action first shall have priority.		
5.3	**Special Operational Considerations**								
5.3.1	Video images accessible to agencies	5.1.4	The System shall support operation by multiple concurrent users/operators	4.1.16	The System shall support the ability for multiple users to monitor the same data item.	4.1.38	*The System shall have the ability to create reports* containing current and historical data. *The System shall support the ability for multiple users to monitor the same data items.*		
						4.6.8	CCTV cameras shall have multiple control functions such as focus, presets, iris adjustments as well as pan, tilt and zoom (if so equipped) which can be accessed locally and remotely.		
				4.1.18	The System shall allow each Agency to exercise full control over ITS elements owned by that Agency.	4.1.28	During normal operations, each Agency shall have primary privileges over field elements in their		

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ConOps Reference Section	ConOps Description	Functional Requirements Section	Functional Requirements Description	High Level Requirements Reference Section	High Level Requirements Description	Detailed Design Requirements Reference Section	Detailed Design Requirements Description	Test Procedure	Comments
							own jurisdiction		
				4.1.23	The System shall support authorized user access via the internet	4.1.25	Users shall be able to access the System via the Internet with the same privileges as if they were on a System workstation		
						4.2.3	The application shall launch and operate within a web browser and shall not utilize any 3rd party remote web access, web application delivery or virtual networking tools to achieve/simulate a web application.		
				4.1.25	The System shall support compliance with all interagency agreements.	4.1.40	Same as High Level Requirement		
5.3.1	Prohibit video recording		In spec						
5.3.1	Block camera fields of view		In spec						
5.3.2	Share joint control of cameras	5.1.4	The System shall support operation by multiple concurrent users/operators	4.1.16	The System shall support the ability for multiple users to monitor the same data item.	4.1.38	*The System shall have the ability to create reports* containing current and historical data. *The System shall support the ability for multiple users to monitor the same data items.*		
				4.1.18	The System shall allow each Agency to exercise full control over ITS elements owned by that Agency.	4.1.28	During normal operations, each Agency shall have primary privileges over field elements in their own jurisdiction		
				4.1.23	The System shall support authorized user access via the internet	4.1.25	Users shall be able to access the System via the Internet with the same privileges as if they were on a System workstation		
						4.2.3	The application shall launch and operate within a web browser and shall not utilize any 3rd party remote web access, web application delivery or virtual networking tools to achieve/simulate a web application.		
				4.1.25	The System shall support compliance with all interagency agreements.	4.1.40	Same as High Level Requirement		
		5.1.5	The System shall support non-incident operation by multiple jurisdictions.	4.1.18	The System shall allow each Agency to exercise full control over ITS elements	4.1.28	During normal operations, each Agency shall have		

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ConOps Reference Section	ConOps Description	Functional Requirements Section	Functional Requirements Description	High Level Requirements Reference Section	High Level Requirements Description	Detailed Design Requirements Reference Section	Detailed Design Requirements Description	Test Procedure	Comments
					owned by that Agency.		primary privileges over field elements in their own jurisdiction		
		5.4.1	Surveillance shall be used to help view the surface transportation system.	4.6.1	The Subsystem shall support the video monitoring of selected arterial locations and midblock locations to provide information regarding traffic conditions.	4.6.1	Same as High Level Requirement		
						4.6.4	The user shall be able to select and view any CCTV camera in the Subsystem		
						4.6.5	CCTV images from all cameras shall be viewable sequentially, individually, or simultaneously as a group		
						4.6.7	The Subsystem shall support both PTZ and fixed cameras		
				4.6.2	Each CCTV camera shall transmit a color image.	4.6.2	Same as High Level Requirement		
				4.6.3	Camera images shall conform to NTSC standards.	4.6.3	Same as High Level Requirement		
				4.6.5	All video shall be a minimum of 10 frames per second.	4.6.6	Same as High Level Requirement		
5.3.3	Allow video use by public	Through Caltrans							
5.4	**Operations of Supporting Functions**								
5.4.1	Advanced At-grade crossing warning and coordination system	Future							
5.4.2	Provide bus location	Future							
5.4.2	Provide transit travel time Information	Future							
5.4.3	Provide arterial travel times	Future							
5.4.4	Overall system integration	5.1.3	The System shall be capable of interfacing with existing and planned ITS elements at all TMC levels.	4.1.2	The System shall work with different makes and models of equipment intended for the same purpose.	4.1.3	Same as High Level Requirement		
						4.1.5	The System shall implement only published standards with any amendments to be approved by Caltrans		

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						4.1.6	Standards shall include the following industry standards groups as applicable at a minimum:		
						4.1.54	The System shall be vendor- and model-independent		
						4.6.9	The Subsystem shall support serial and/or IP communication for camera control.		
						4.6.10	The Subsystem shall support multiple camera controllers using different protocols.		
				4.1.9	The System shall be capable of interfacing with existing and planned ITS elements at the local and regional levels.	4.1.13	At the local level, the System shall be capable of interfacing with existing fiber networks and System-compatible controllers		
						4.1.14	At the regional level, the System shall be capable of interfacing with the existing BART fiber backbone and with the D4TMC ATMS		
						4.1.49	Proprietary protocols shall be used only when necessary to communicate to existing devices that do not support NTCIP communications protocols		
						4.7.6	The System shall be capable of interfacing with all legacy vehicle detector sensors		
		5.1.8	The System shall be able to be expanded	4.1.10	The System shall be expandable through the following methods: adding ITS elements, expanding geographically	4.1.15	The System shall have the capability of being expanded to cover the entire corridor in the County of San Mateo.		
						4.1.16	The System software shall have the capability of being expanded along the likely diversion routes in San Mateo County and being expanded to the following ultimate number of devices:		

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						4.1.47	Within each Subsystem, the components shall be capable of being added in a modular fashion.		
						4.8.16	The Communications Subsystem shall be expandable to accommodate at least 25% more field devices of each type than currently planned and accommodate a minimum of 30% excess bandwidth for future network traffic		
				4.1.11	System expansion shall meet the following conditions: expansion shall not result in a decrease in System performance, expansion shall not be dependent on redesign of any components.	4.1.17	As devices are added to the System, this shall only involve additions to the database without a reconfiguration or redesign of the System		
						4.1.18	The System shall be capable of supporting all users concurrently without a noticeable change in System performance. The system view shall not be delayed by more than 2 seconds as compared to the pilot project when the system is at ultimate size.		
						4.1.19	At the ultimate size, the operation of the field devices shall be unaffected by the additional devices with no increase in latency		
						4.1.50	Changes in the database resulting from future expansion and additional ITS elements shall involve a smooth and seamless integration.		
				4.6.4	The Subsystem shall support individual CCTV cameras, expandable to the limits of the Subsystem hardware.	4.1.16	The System software shall have the capability of being expanded along the Smart Corridor in San Mateo County and being expanded to the following ultimate number of devices:		

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ConOps Reference Section	ConOps Description	Functional Requirements Section	Functional Requirements Description	High Level Requirements Reference Section	High Level Requirements Description	Detailed Design Requirements Reference Section	Detailed Design Requirements Description	Test Procedure	Comments
6.0	**Performance Measures**	5.1.17	The System shall be able to collect data that can be used to determine conformance with performance measures.						
	Percentage of incidents that do not require active traffic monitoring on local streets			4.1.32	Performance measures shall be established for each System, Subsystem and individual ITS element.	4.1.57	System performance measures shall be based on reliability measures and on the following:		
	Results of user surveys on the use of the Smart Corridor tools					4.2.17	The Traffic Control Subsystem shall have the following performance measures:		
	Reduction in measured congestion					4.3.8	Controllers shall have the following performance measures:		
	Reductions in system travel time					4.4.17	Directional signs shall have the following performance measures:		
	Reduction in queue clearance time					4.5.13	ADMS shall have the following performance measures:		
	Reduction in amount of traffic filtering through the local network					4.6.14	The CCTV Subsystem shall have the following performance measures:		
	Average time after an incident Caltrans notifies local agencies					4.7.8	The Detection Subsystem shall have the following performance measures:		
	Average time to deploy an alternate route					4.8.26	The Communications Subsystem shall have the following performance measures:		
	Average time required for traffic signals to transition to flush plan					4.3.7	Controllers shall meet either NEMA TS2, or be compatible with Model 2070 or Model 2070 Lite requirements in the TEES		
	Percentage of time that the use of Smart Corridor devices provides satisfactory traffic flow					4.1.57	System performance measures shall be based on reliability measures and on the following:		
	Amount for sources expended for managing alternate route					4.1.57	System performance measures shall be based on reliability measures and on the following:		